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Smart Grid: Core Firms in the Research Triangle Region, NC

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None of the opinions or comments expressed in this study are endorsed by the companies mentioned or individuals interviewed. Errors of fact or interpretation remain exclusively with the authors. We welcome comments and suggestions.

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List of Abbreviations

AC	Alternating Current
AMI	Advanced Metering Infrastructure
ARPA-E	Advanced Research Projects Agency – Energy
CGGC	Center on Globalization, Governance & Competitiveness
C/I	Commercial/Industrial
CIS	Customer Information Systems
DARPA	Defense Advanced Research Projects Agency
DC	Direct Current
DMS	Distribution Management System
DOE	Department of Energy
EIA	Energy Information Administration
EPRI	Electric Power Research Institute
EMS	Energy Management System
ERP	Enterprise Resource Planning Software
EV	Electric Vehicle
FREEDM	Future Renewable Electric Energy Delivery and Management
G2V	Grid-To-Vehicle
GIS	Geographic Information System
HVAC	Heating, Ventilation And Air Conditioning
HVDC	High-Voltage Direct Current
IEA	International Energy Agency
IT	Information Technology
NETL	National Energy Technology Laboratory
NCSEA	North Carolina Sustainable Energy Association
NCSU	North Carolina State University
NIST	National Institute of Standards And Technology
OECD	Organization for Economic Co-Operation and Development
PMU	Phasor Measurement Units
PNNL	Pacific Northwest National Laboratory
R&D	Research and Development
RF	Radio Frequency
RPS	Renewable Portfolio Standard
RTP	Research Triangle Park
SCADA	Supervisory Control and Data Acquisition
V2G	Vehicle-To-Grid
WAMS	Wide-Area Monitoring Systems
WIMAX	Worldwide Interoperability for Microwave Access

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Executive Summary

Smart grid refers to the transformation of the electric power system into an "energy Internet," allowing utilities and customers to share information in real time, often automatically, so that both sides can more effectively manage electricity use. A smart grid promises to make the outdated U.S. power system more reliable, preventing outages and blackouts, which cost the nation an estimated $150 billion annually (U.S. DOE, 2008). Smart grid also could dramatically reduce energy use and emissions. If fully deployed—and accompanied by policy support for decentralized power, renewable power, and electric vehicles—smart grid could reduce energy use and emissions by an estimated 525 million metric tons in 2030, or 18% of the total from the electric sector (PNNL, 2010).[1]

Clearly, in addition to reliability, energy efficiency and other societal benefits, the development of a smart grid will create economic opportunities. Many U.S. vendors are moving quickly to provide a widening array of new devices, software, controls, communications, and services. U.S. firms large and small are finding new niches domestically and tapping into export markets.

This analysis focuses specifically on core smart grid firms and relevant assets in North Carolina in general, and in the 13-county Research Triangle Region in particular. We address 1) North Carolina firms' leadership role nationally, 2) the state's exceptional smart grid assets, 3) the Triangle's wide diversity of smart grid firms (the "who"), 4) Triangle firms' specific capabilities across the value chain (the "what"), and 5) Triangle firms' positioning in areas of likely future investment—including possible areas to target for further development of the region's smart grid leadership in the nation and around the globe. Key findings include the following:

1) **North Carolina is a hotspot for smart grid firms**. A recent national study by Duke University's Center on Globalization, Governance & Competitiveness (CGGC) found a striking concentration of leading smart grid vendor firms in North Carolina. Only the state of California had substantially more locations.[2] As for top cities in headquarter locations, Raleigh, North Carolina had five headquarter locations for lead firms, second only to San Francisco, CA with six headquarter locations (Lowe et al., 2011).
2) **North Carolina has a concentration of exceptional smart grid assets**. North Carolina has a number of institutions already contributing to smart grid development, including specialized R&D centers, Tier I research universities, energy efficiency and renewable energy firms, and supportive government and non-profit agencies. The upcoming merger of Charlotte-based Duke Energy and Raleigh-based Progress Energy will create the nation's largest utility, with 7.1 million customers.
3) **The Research Triangle has at least 59 core smart grid firms.** A total of 101 Triangle locations are engaged in developing or manufacturing relevant hardware, developing

[1] Baseline 2030 emissions as forecast by the U.S. Energy Information Agency (EIA).

[2] Locations refer to facilities where smart grid technologies are developed or manufactured, or services performed.

software, or performing services.[3] Within the Research Triangle, these locations are overwhelmingly concentrated in Wake County (64 locations) and Durham County (21 locations). Firms include multinationals in power systems (ABB, GE, Siemens), information technology (Cisco, IBM), and energy services (Honeywell, Johnson Controls), as well as small specialty ventures (GRIDiant, Plotwatt). They already employ an estimated 3,000 people working in the Triangle on smart grid technologies.

4) **Research Triangle firms span the entire smart grid value chain**. The Triangle has a number of firms in each of the eight smart grid technology categories identified by the International Energy Agency (IEA).[4] The highest number of firms appear in information and communications technology integration, followed by building energy management, and advanced metering infrastructure (see Figure 4 on page 19). Overall, Triangle firms are more involved in smart grid software or services than in hardware, with 35 of the 59 identified firms appearing in one or more hardware categories, while 44 firms appear in software and/or services.
5) **Many Triangle firms are positioned in areas of likely future investment**. The three largest future investment categories in smart grid are expected to be distribution grid management, transmission enhancement, and information technology/ communications integration. The latter is the category with the highest involvement to date by Research Triangle firms. Possible areas to seek a larger presence for Triangle firms are distribution grid management and transmission enhancement, reflecting the smart grid's extensive "second wave"— a focus on distributing intelligence and communications throughout the entire system from power generation through transmission and distribution to end users.

The Research Triangle Region and state of North Carolina have a unique opportunity not only to invent, manufacture, and sell smart grid technologies to the world, but also to apply them at home. The merger of Duke Energy and Progress Energy, creating the nation's largest utility, may offer economies of scale that can facilitate smart grid deployment.

To make the most of this opportunity will require targeted policy support, however. In the post-stimulus period it will be important to create a policy environment conducive to further private investment in smart grid. It will also require regulatory reform and, more important, fundamental changes in the electricity sector's prevailing business model, which incentivizes utilities to sell more, not less energy. Such changes will require a coordinated effort on the part of policy makers and regulators, as well as other stakeholders including industry and non-profit institutions. No less important is education of the public so that consumers not only understand the need to update the outdated electric system, but also recognize the potential of the smart grid to reduce energy use and CO_2 emissions, deliver reliable power, stimulate innovation, and create local jobs.

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[4] All figures and tables in this report follow the IEA's eight-technology framework.

Introduction

Smart grid refers to the transformation of the electric power system into an "energy Internet," allowing utilities and customers to share information in real time, often automatically, so that both sides can more effectively manage electricity use. A smart grid promises to make the outdated U.S. power system more reliable, preventing outages and blackouts, which cost the nation an estimated $150 billion annually (U.S. DOE, 2008). Smart grid also could dramatically reduce energy use and emissions. If fully deployed—and accompanied by policy support for decentralized power, renewable power, and electric vehicles—smart grid could reduce energy use and emissions by an estimated 525 million metric tons in 2030, or 18% of the total from the electric sector (PNNL, 2010).[5]

Investment in smart grid has grown rapidly in the past few years. Through its Smart Grid Investment Grant Program, the U.S. Department of Energy (DOE) provided $3.4 billion for smart grid technology deployments, matched by $4.7 billion in private sector funding (Zpryme, 2010). Nationwide, utilities now have more than 200 smart grid projects underway (Smart Grid Information Clearinghouse, 2011). The Electric Power Research Institute (EPRI) estimates that fully implementing a U.S. smart grid over the next two decades will require an investment of $338 billion to $476 billion, resulting in benefits of $1.3 trillion to $2 trillion (EPRI, 2011). Whether these future U.S. investments will materialize remains to be seen. However, the global market for smart grid products is expected to exceed $186 billion by 2015 (SBI Energy, 2010).

Clearly, in addition to reliability, energy efficiency and other societal benefits, the development of a smart grid will create economic opportunities. Many U.S. vendors are moving quickly to provide a widening array of new devices, software, controls, communications, and services. U.S. firms large and small are finding new niches domestically and tapping into export markets.

A recent national study by Duke University's Center on Globalization, Governance & Competitiveness (CGGC) found that a striking concentration of leading smart grid vendor firms are located in North Carolina in general, and in the Research Triangle Region in particular.[6] This report will build on that U.S. study, this time focusing on core smart grid firms operating in the Research Triangle Region. We will address 1) North Carolina firms' leadership role nationally, 2) the state's exceptional smart grid assets, 3) the Triangle's wide diversity of smart grid firms (the "who"), 4) Triangle firms' specific capabilities across the value chain (the "what"), and 5) Triangle firms' positioning in areas of likely future investment, including possible areas to target for further development of the region's smart grid leadership in the nation and around the globe.

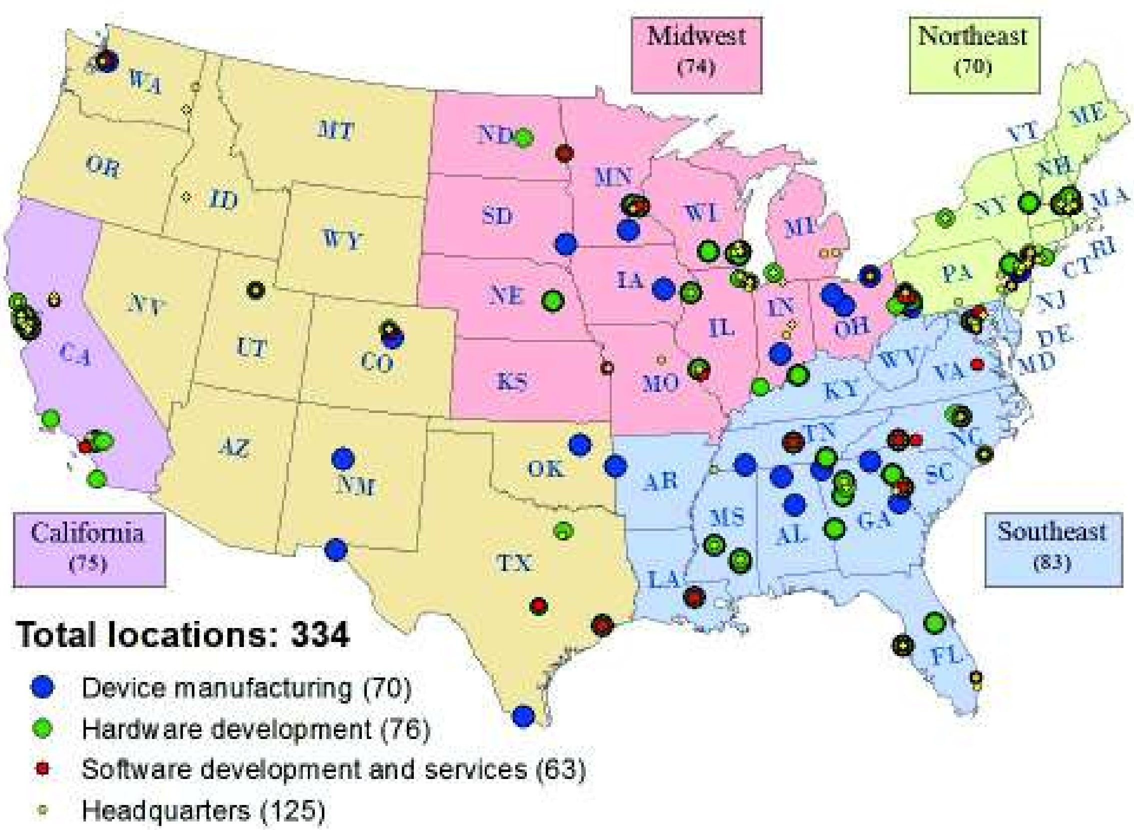
[5] Baseline 2030 emissions as forecast by the U.S. Energy Information Agency (EIA).

[6] "U.S. Smart Grid: Finding New Ways to Cut Carbon and Create Jobs" (Lowe et al., 2011).

North Carolina is a hotspot for smart grid firms

In CGGC's recent analysis of 125 leading smart grid vendors with employee locations in the United States, North Carolina stood out for its high concentration of locations (see Figure 1).[7] In the 125-firm sample, the Southeast as a whole had the highest total number of locations (83), with California next, essentially constituting its own region with 75 locations. After California, other top states included Pennsylvania (21), North Carolina (19) and Wisconsin (18). Thus, while Pennsylvania had slightly more locations than North Carolina, only one state—California—had substantially more locations. As for top cities in headquarter locations, Raleigh, North Carolina had five headquarter locations for lead firms, second only to San Francisco, CA with six headquarter locations (Lowe et al., 2011).

Figure 1. Relevant employee locations of leading U.S. smart grid vendors



Note: Not exhaustive. Based on sample of 125 lead firms. Software development and services (63 sites) is an undercount, since these activities often are also performed at company headquarter sites.

Source: CGGC, based on industry interviews and company websites.

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[7] Locations refer to facilities where smart grid technologies are developed or manufactured, or services performed.

North Carolina has a concentration of exceptional smart grid assets

In addition to core smart grid firms, the Research Triangle Region and state of North Carolina have a number of institutions already contributing to smart grid development. The scope of this report does not include a full inventory of such assets. However, even a cursory look yields a list of outstanding examples directly related to smart grid, including the following:

Specialized R&D Centers. North Carolina State University's Future Renewable Electric Energy Delivery and Management Systems (FREEDM) Center has developed a "smart transformer" that will help incorporate solar and wind power reliably into the grid and recharge electric vehicles more quickly. A test version is expected to be ready in two years. This local invention appears on the Massachusetts Institute of Technology's 2011 list of the world's 10 most important emerging technologies (Freedman, 2011).

Universities, colleges, engineering talent and highly trained work force. The Research Triangle alone has three Tier I research universities, nine other colleges and universities, and seven community colleges. An estimated 44% of the RTP workforce holds college degrees (Research Triangle Regional Partnership, 2011). Several centers at area universities provide targeted support for commercializing student and faculty inventions and stimulating entrepreneurship.

Energy efficiency and renewable energy firms. North Carolina has a large and well-documented number of establishments engaged in these industries. The 2010 North Carolina Renewable Energy and Energy Efficiency Census, conducted by North Carolina Sustainable Energy Association (NCSEA), provides data on 546 such firms statewide (NCSEA, 2010).

Embrace of electric vehicles. The Research Triangle is a partner in Project Get Ready, a national effort to prepare cities for plug-in electric vehicles. Raleigh has already become a leader in facilitating EV charging stations by creating a permitting and inspection process that can be completed in as few as two days. Raleigh-based utility Progress Energy is working on infrastructure and financial incentives for EV adoption and is including plug-in hybrid and electric vehicles in its utility fleet (U.S. DOE, 2011). The U.S. supply chain for the advanced batteries that go into electric vehicles encompasses several important North Carolina firms, including global leaders such as Celgard (20-30% share of the global market for separators), Chemetall and FMC (together supplying nearly 50% of the world's demand for lithium) (Lowe et al., 2010).

Fort Bragg microgrid. The U.S. Army base near Fayetteville, NC has one of the world's largest microgrids. The post has its own distribution system and supplements utility power with on-site generation. A number of smart features make the microgrid a useful test case and proving ground for emerging smart grid projects.

Supportive government and non-profit agencies. North Carolina is one of 29 states (and the District of Columbia) with a renewable portfolio standard (RPS). RPS requires a percentage share of an electric provider's energy sales to come from renewable sources, providing a potential market for relevant smart grid technologies. The North Carolina Solar Center manages the national Database of State Incentives for Renewables & Efficiency (DSIRE), which lists all incentives and policies for energy efficiency and renewable energy in the United States. Raleigh-based non-profit Advanced Energy conducts cutting-edge research on energy efficiency and electric transportation. A wide range of North Carolina institutions is actively supporting smart grid development, including economic development agencies, renewable energy advocates, and venture capital firms.

Nation's largest utility. Charlotte-based Duke Energy and Raleigh-based Progress Energy have announced their upcoming merger, which will create the largest U.S. utility, with 7.1 million customers. In 2011, Progress Energy was named among the country's top 10 utilities for investment in demand-side management, an important approach for smart grid (Zpryme, 2011). Duke Energy helped create the Envision Center on the Centennial Campus of North Carolina State University (NCSU) to promote public awareness of smart grid. The company has allocated $1 billion for smart grid in the states it serves (Duke Energy, 2011). It has recently signed a partnership with DOE and the Electric Power Research Institute (EPRI) to find ways to test and deploy the Advanced Research Projects Agency – Energy (ARPA-E) smart grid projects (ARPA-E, 2011).[8]

Although additional research is needed to document the full extent of North Carolina's relevant assets, this brief overview makes clear that the state has a notable convergence of institutions that are well-positioned to provide leadership in smart grid, nationally and globally.

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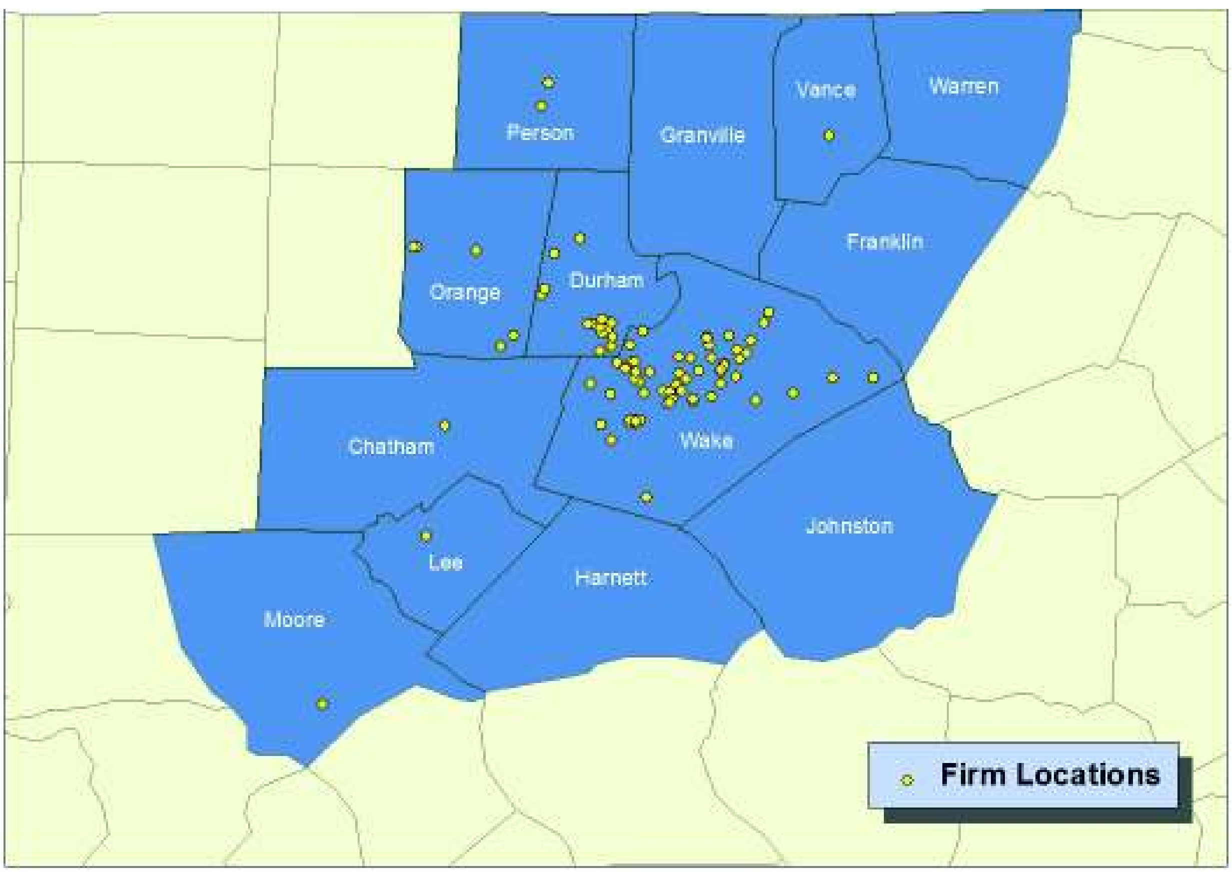
[8] ARPA-E is the U.S. Advanced Research Projects Agency-Energy, modeled after the Defense Advanced Research Projects Agency (DARPA), the agency responsible for technology innovations such as the internet. Now in its fourth round of funding, ARPA-E recently announced that six of its projects had secured private capital investments over $100 million (ARPA-E, 2011).

The Research Triangle Region has at least 59 core smart grid firms

CGGC's recent U.S. smart grid study focused broadly across all states without looking in-depth at any one metropolitan area or region—thus uncovering only a sample of the 125 most salient firms and 334 locations. A more fine-grained focus at the metropolitan level would likely have uncovered more firms and locations in any given metro area.

In this follow-up analysis, by contrast, our research does indeed focus specifically on the Research Triangle Region. This report is thus able to go beyond the national 125-firm sample and identify a number of core smart grid firm locations in addition to those that appeared in the national study. As shown in Figure 2, we thus found at least 59 smart grid firms currently active in the 13-county Research Triangle Region, with a total of 101 employee locations engaged in developing or manufacturing relevant hardware, developing software, or performing services. Within the Research Triangle, these locations are overwhelmingly concentrated in Wake County (64 locations) and Durham County (21 locations).

Figure 2. Employee locations of core smart grid firms in the Research Triangle



Total: 101 locations

Source: CGGC, based on industry interviews and company websites.

The smart grid brings together a wide range of vendors, power providers, investors, regulators, government agencies, research institutions, and standard-setting organizations. In this study we focus on the vendors—a category that comprises hundreds of firms nationwide[9] from a broad array of industries. Smart grid vendors constitute a large and rapidly evolving industry marked by many new entrants, new technologies, and new capabilities gained through strategic mergers and acquisitions.

The following is a list of the major types of firms involved in smart grid. Names in parentheses are selected examples of firms with Research Triangle locations that are engaged in developing or manufacturing smart grid hardware, developing software, or performing services.

- **"Legacy" power firms** that have traditionally provided electric equipment and are now involved in smart grid-related hardware, software and services (ABB, GE, Siemens)
- **IT firms** that provide communications, networking, and data management (Cisco, IBM, SAP, SAS Institute)
- **Communications firms** that provide products for advanced metering infrastructure (Alcatel-Lucent, Consert, Freescale Semiconductor)
- **Meter hardware firms** that provide smart meters (Elster, Itron, Sensus)
- **Energy management firms** that provide automation, monitoring, and control systems for buildings (Honeywell, Johnson Controls, Schneider Electric)
- **Telecom service firms** that provide cellular network access (AT&T, Sprint, Verizon)
- **Consulting firms** that offer business and technical services to utilities, corporations and governments making decisions about smart grid networks (Accenture, KEMA)
- **Small smart grid firms** that have capabilities across several technology areas (GRIDiant, Nexant, Power Secure, Tantalus)
- **Small specialty firms** that focus in one technology area with important applications for smart grid (Consonus, Doble Engineering, Mega Watt Solar, Plotwatt, Truveon)

Further research is needed to make a comprehensive count of the jobs represented by Triangle smart grid firms. However, a preliminary estimate prepared on behalf of Raleigh Economic Development suggests that 3,000 people in the Triangle are directly involved in smart grid technologies. This number is considered to be conservative (Denny, 2011).

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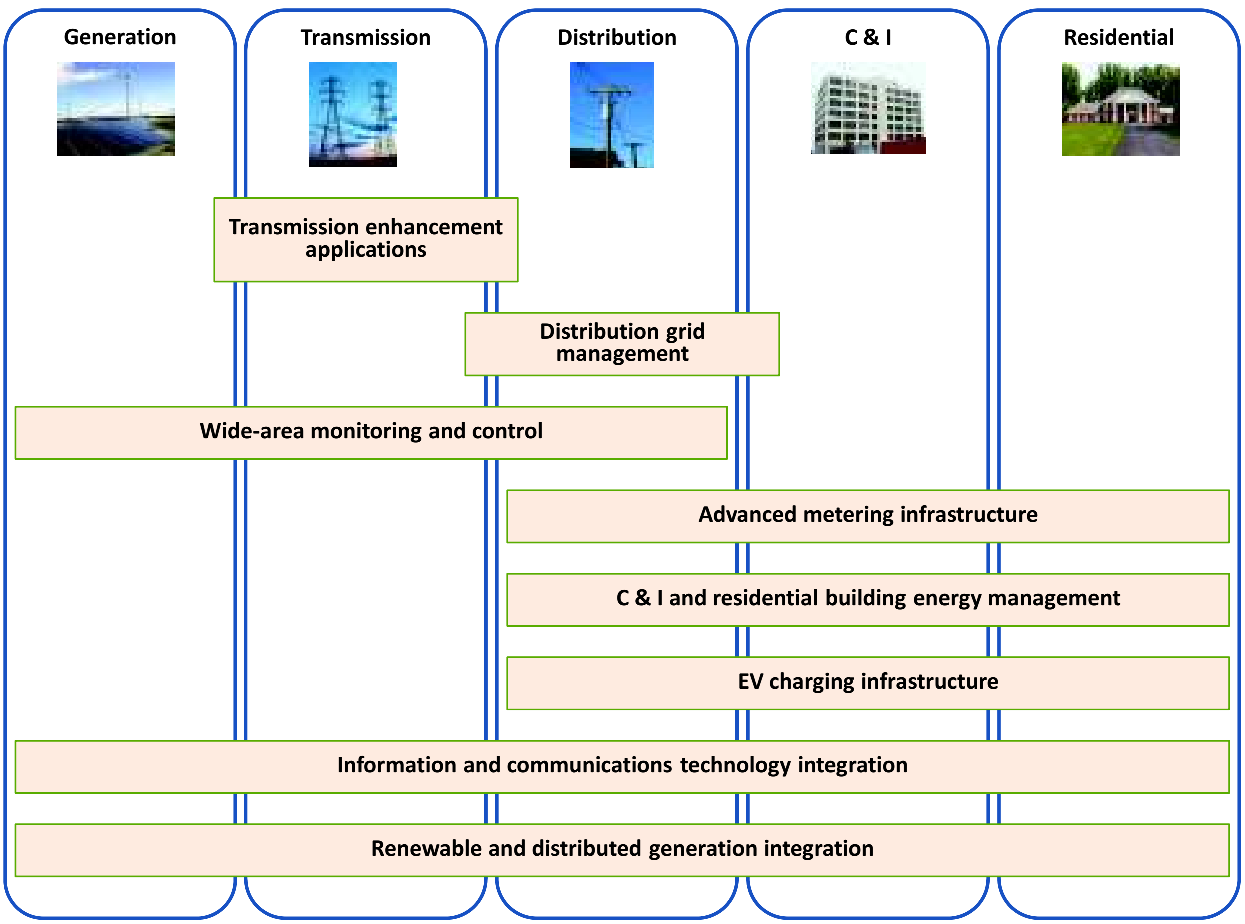
[9] In its report, *2010 U.S. Smart Grid Vendor Ecosystem*, the Cleantech Group drew on a database of 600 relevant U.S. firms. Our simplified list of vendor types is based on the Cleantech Group's much more in-depth analysis.

Research Triangle firms span the entire smart grid value chain

Our depiction of the U.S. value chain for smart grid vendors is found in Figure 3. The left-to-right structure begins with power generation, moves through transmission and distribution, and ends with consumption. This roughly parallels the process in which electric power is delivered to the customer: first electricity is generated, then it is stepped up by transformers to a high voltage so it can be transmitted over long distances (similar to the way high water pressure is needed to transport water), then it arrives at a substation, where it is stepped back down to a lower voltage safer for local distribution. Most smart grid activity so far has focused not on transmission but on the distribution side of the chain—the part that stretches from the substation to the customer.

Figure 3. Smart grid vendor value chain



Note: C&I refers to commercial and industrial

Source: Eight technology categories from IEA, 2011, based on DOE's National Energy Technology Laboratory (NETL) and the National Institute of Standards and Technology (NIST).

Each horizontal bar in Figure 3 represents one of the eight main smart grid technology areas identified by the International Energy Agency (IEA, 2011). Technology categories stretch across one or more stages of electric power delivery, from generation through transmission and distribution, to consumption. Their functions can be described as follows:[10]

- **Transmission enhancement applications** involve a number of technologies that can make transmission networks more controllable, maximize the transfer of power, reduce transmission losses, and decrease the risk of overloads. Advanced transformers reduce electricity losses compared to conventional transformers, devices that reduce the voltage of electricity so it can be safely distributed to neighborhoods. New transformer designs greatly reduce the waste of electricity during distribution.

- **Distribution grid management** combines sensor technologies and automation to continuously maintain voltage levels, locate faults, reconfigure feeders, and control distributed generation so that equipment performs optimally and outages are minimized.

- **Wide area monitoring and control** helps system operators monitor, control and optimize the power system over large geographic areas, avoiding blackouts and facilitating the use of renewables. Advanced system analytics generate data used to inform decisions and make systems more reliable.

- **Advanced Metering Infrastructure (AMI).** The foundation of the smart grid's two-way flow of data, and the key to most smart grid efforts to date, is the underlying infrastructure that combines smart meters, communications and data management. AMI involves a number of functions, including smart meters, the network infrastructure to transmit data from smart meters to the utility, and software to compile and manage the massive quantities of data produced**.**

- **Commercial, Industrial or Residential Building Energy Management.** Large firms such as Johnson Controls and Honeywell have provided building automation systems for years, but firms are now making these customer-side systems more integrated, using networked sensors and monitors and incorporating data from individual systems such as lighting and heating, ventilation and air conditioning (HVAC). New technologies include energy dashboards, smart appliances, and local energy storage. An important smart grid application is "Demand Response," including cutting demand through voluntary agreements with power customers**.** To create a large pool of capacity to reduce peak power loads through demand response, utilities turn to curtailment service providers.

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[10] These technology categories were drawn from IEA, 2011, based on DOE's National Energy Technology Laboratory (NETL) and the National Institute of Standards and Technology (NIST). For functional descriptions, we also drew on Neichin & Cheng, 2010. We encourage readers to refer to the IEA and Neichin reports for more in-depth analysis.

Although demand response is primarily a service model, specific hardware is required to achieve the necessary communication, monitoring, control and automation.

- **Electric vehicle charging infrastructure.** Electric vehicles rely on energy storage in the form of advanced vehicle batteries.[11] Connecting electric vehicles to the grid for battery recharging requires infrastructure to handle billing, scheduling and other intelligent functions. If charging stations allow power to flow both ways, electric vehicles can serve as a source of distributed energy storage—discharging electricity back to the grid during hours when the vehicle is parked and peak power is needed.

- **Information and communications technology integration** make it possible to integrate intelligence throughout the entire power system, and to achieve real time, two-way communication in order to manage energy more effectively.

- **Renewable and distributed generation integration** require connecting solar arrays, wind farms and other sources to power grids. This involves new products in addition to standard technologies used to connect traditional sources such as coal and nuclear. Because solar panels produce direct current (DC), they require inverters to convert DC to alternating current (AC) power. Accommodating small-scale, distributed power sources such as rooftop solar requires different capabilities from grid-scale renewable sources such as a concentrating solar array. Energy storage can play a key role in neutralizing the variable nature of renewables by supplying energy at times of no sun or wind. The storage device itself is required, along with converters (rectifier inverters), and traditional field equipment associated with conventional power.

Each of the eight categories described above comprises a number of smart grid technologies involving various configurations of hardware, software, communications and services. Examples of the kinds of products found in each category are shown in Table 1.

[11] For a U.S. value chain analysis of lithium-ion batteries for vehicles, see the CGGC report, "Lithium-ion Batteries for Electric Vehicles: The U.S. Value Chain" (Lowe et al., 2010).

Table 1. Smart grid technology categories, and examples of hardware, software or systems

Technology category	Examples of hardware	Examples of software or systems
Transmission enhancement	Superconductors, FACTS, HVDC High-voltage direct current (HVDC). **Advanced transformers:** High-efficiency amorphous transformers, solid state transformers (under development)	Network stability analysis, automatic recovery systems. Advanced transformer asset management systems
Distribution grid management	Automated re-closers, switches and capacitors, remote controlled distributed generation and storage, transformer sensors, wire and cable sensors, distribution management systems	Geographic information system (GIS), distribution management system (DMS), outage management system (OMS), workforce management system (WMS)
Wide area monitoring & control	Phasor measurement units (PMU) and other sensor equipment	Supervisory control and data acquisition (SCADA), wide-area monitoring systems (WAMS), wide-area adaptive protection, control and automation (WAAPCA), wide-area situational awareness (WASA)
Advanced metering infrastructure	Smart meters, in-home displays, servers, relays	Meter data management system (MDMS)

Technology category	Examples of hardware	Examples of software or systems
C/I building or home energy management	Smart appliances, routers, in-home display, Building automation systems, smart appliances, routers, in-home displays, **demand response** enabling devices	Energy dashboards, energy management systems, energy applications for smart phones and tablets, **demand response** curtailment services
Electric vehicle charging infrastructure	Charging infrastructure, batteries, inverters	Energy billing, smart grid-to-vehicle charging (G2V) and discharging vehicle-to-gird (V2G) methodologies
IT & communications technology integration	Communication equipment (Power line carrier, WIMAX, RF mesh network, cellular), routers, relays, switches, gateway, computers (servers)	Enterprise resource planning software (ERP), Customer information systems (CIS)
Renewable & distributed generation integration	Power conditioning equipment for bulk power and grid support, communication and control hardware for generation and enabling storage technology; **energy storage:** advanced batteries, capacitors, fuel cells, compressed air, pumped storage	Energy management system (EMS), distribution management system (DMS), SCADA, geographic information system (GIS), battery management systems

Source: Adapted from (IEA, 2011).

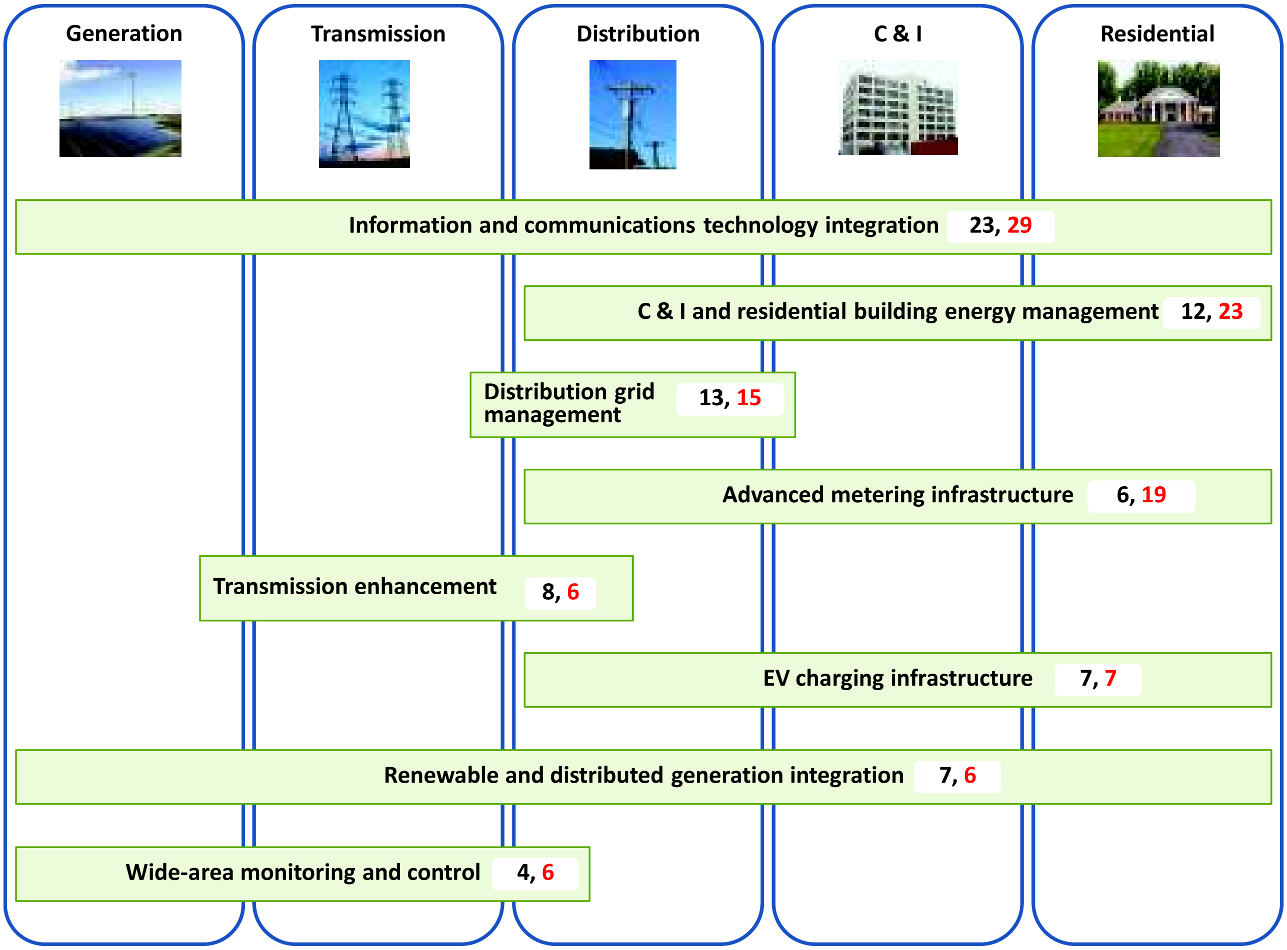
To identify the capabilities of Research Triangle firms, we did a firm-by-firm inventory across the spectrum of eight smart grid technology categories identified by the IEA. This analysis is far from exhaustive, and it is only a snapshot in a rapidly evolving industry marked by many new entrants, new technologies, and new capabilities gained through mergers and acquisitions. Moreover, the information is based on firms' self-reporting via company websites and brief interviews; the research did not include independently verifying companies' actual orders for the products areas each firm reported being involved in.

Despite these data limitations, the analysis yields several useful conclusions about the breadth of capabilities of Research Triangle smart grid firms. Figure 4 summarizes the footprint of Research Triangle firms across the smart grid value chain, according to numbers of firms. The technology categories appear in order of most involvement to least. Black font denotes the number of firms providing hardware for smart grid, while red font denotes those that provide software and services. Firm numbers add up to more than the total of 59 firms because many have a footprint in several categories. These data reveal the following:

- The 13-county Research Triangle Region has a number of firms involved in each of the eight technology categories. The highest number of firms appears in information and communications technology integration (23 in hardware, 29 in software/services). This is not surprising, given that IT / communications is fundamental to nearly all smart grid efforts and stretches across the entire value chain.
- Other top categories in number of firms are building energy management, in which many firms were involved long before the advent of the smart grid (12 hardware, 23 software), and distribution grid management (13 hardware, 15 software).
- The multinational "legacy power firms" (ABB, GE, Siemens) have a broad footprint stretching across nearly all categories. Most firms (32) participate in at least two categories. Twenty-seven firms appear in one category only, ranging from large telecom firms (AT&T) to medium-sized IT firms (Red Hat), to small engineering firms (Doble Engineering).
- Overall, Research Triangle firms are more involved in smart grid software and services than in hardware, with 35 of the 59 identified firms appearing in one or more hardware categories, while 44 firms appear in software and/or services.

Other measures could certainly be used to measure firms' involvement, for instance total number of local employees devoted to these activities, or total value of relevant products sold. Unfortunately, such data are neither publicly available nor likely obtainable through direct contacts with firms. This study does give a sense, however, of the wide diversity of capabilities offered by firms in the Research Triangle Region. For a summary table listing all the firms and their relevant technology categories, see Table 2. For the complete set of data presented in a firm-by-firm matrix, see the Appendix on page 27.

Figure 4. Capabilities of Research Triangle firms in smart grid (numbers of firms)



Note: Technology categories (horizontal bars) appear in order of highest to lowest number of involved firms.

Numbers in black font refer to firms involved in hardware; numbers in red font refer to firms involved in software and/or services.

Source: Technology framework based on IEA, 2011; firm-level data based on company websites and interviews.

Table 2. Capabilities of Research Triangle firms in smart grid (names of firms)

Technology	Companies
IT and communications technology integration	ABB, Accenture, Alcatel-Lucent, AT&T, Aviat Networks, Black & Veatch, Brocade, Cisco, Consert, Consonus Technologies, Control Infotech, Cree, Cypress Semiconductor, Delta Electronics, Eaton, Elster Solutions, EMC, Freescale Semiconductor, GE, Green Energy Corp, GRIDiant, IBM, Itron, Johnson Controls, KEMA, MasTec, Nitronex, Power Analytics, Quanta Technology, Red Hat, SAP, Schneider Electric, Sensus, Sprint, STMicro-electronics, Sun Microsystems, Tantalus, Telit Wireless Solutions, Triangle MicroWorks, Underwriters Laboratories (UL), Virtual Computing Environment, Ventyx, Verizon, Wesco Distribution*
C/ I building & home energy management	ABB, Accenture, Cisco, Consert, Cree, Delta Electronics, Eaton, Elster, GE, Google, GRIDiant, Honeywell, IBM, Itron, Johnson Controls, KEMA, NEXANT, Plotwatt, Power Analytics, Power Secure, SAS Institute, Schneider Electric, Siemens Energy, Tantalus, Truveon, UL
Distribution grid management	ABB, Accenture, Control Infotech, DNA Group, Doble Engineering Company, Eaton, Elster, GE, Green Energy Corp, GRIDiant, IBM, Itron, Power Secure, Quanta Technology, Schneider Electric, Siemens Energy, TE Connectivity , Wesco Distribution*
Advanced metering infrastructure	Accenture, Consert, Elster, Freescale Semiconductor, GE, Green Energy Corp, Honeywell, IBM, Itron, KEMA, Power Analytics, Power Secure, Quanta Technology, SAP, SAS Institute, Sensus, Siemens Energy, Tantalus Systems, UL, Ventyx

Technology	Companies
Transmission enhancement	ABB, Accenture, Delta Electronics, Eaton, GE, Green Energy Corp, KEMA, NEXANT, Quanta Technology, Schneider Electric, Siemens Energy, TE Connectivity , Wesco Distribution*
EV charging	ABB, Cisco, Consert, Eaton, Elster, GE, Itron, KEMA, Schneider Electric, Siemens Energy, UL
Renewable and distributed generation integration	3DFS Power Solutions, ABB, Elster, GE, Green Energy Corp, Itron, KEMA, Majorpower, MegaWatt Solar, Microcell, Power Analytics, Power Secure, Quanta Technology, Siemens Energy, STMicro-electronics, Underwriters Laboratories
Wide-area monitoring and control	ABB, Elster, Green Energy Corp, IBM, Quanta Technology, Sensus, Siemens Energy

Note: Technology categories (horizontal bars) appear in order of highest to lowest number of involved firms.

Black font refers to firms involved in hardware. Red font refers to firms involved in software and/or services only.Firms that are involved in hardware and software and/or services are in black font.

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Source: Framework based on IEA, 2011; firm-level data based on company websites and interviews.

Many Triangle firms are positioned in areas of likely future investment

To fully understand the footprint of smart grid firms in the Research Triangle, it would be useful to perform an in-depth analysis of strengths and gaps in the value chain. A complete examination, particularly of gaps in capabilities, is beyond the scope of this initial study. However, it is possible to compare the footprint of Triangle firms with areas of expected future investment in smart grid over the next 20 years.

The Electric Power Research Institute (EPRI) recently performed a cost-benefit analysis based on the estimated investment required to create a full-blown smart grid. The analysis concluded that this would require a total of $338 - $476 billion in net investment spread over the 2010-2030 period. Net benefit was estimated at $1,294 - $2,098 billion, or a benefit-to-cost ratio of 2.8 to 6.0 (EPRI, 2011).

These estimates are not predictions. Rather, they demonstrate the investments that would be required to achieve a fully functioning smart grid. Actual investment is likely to be lower, depending on a complex mix of economic and political factors. However, since the EPRI researchers provided a detailed accounting of individual smart grid technologies, their analysis offers a useful overview of the relative size of investment flows likely to go to different technology areas.[12] Differences in investment flows are determined by the per-unit cost of each product and the number of units required.

As shown in Table 3, the three largest future investment categories are expected to be distribution grid management, transmission enhancement, and information technology/ communications integration. The latter is the category with the highest involvement to date by Research Triangle firms. The expected move toward greater investment in distribution grid (third category for Triangle involvement) and transmission (fifth) reflects the smart grid's extensive "second wave"—in which initial investments in advanced metering infrastructure (fourth Triangle category) and building energy management (second) will be followed by a focus on distributing intelligence and communications throughout the entire system. Possible areas to seek a larger footprint for local firms might therefore be distribution grid management and transmission enhancement. The two categories for lowest total investment in the EPRI framework are EV charging and wide-area monitoring and control, which also correspond to areas of less involvement by Research Triangle firms.

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[12] We used EPRI's detailed figures and combined relevant groupings to correspond to the eight IEA-identified categories used throughout this report. Please note that in the wide area monitoring & control category, we only considered phasor measurement units. This investment level is thus an underestimate.

Table 3. EPRI estimates of required investment for a fully functional smart grid

Technology category	Total Cost Low $M	Total Cost High $M
Distribution grid management	163,082	231,067
Transmission enhancement	62,774	66,758
IT and communications integration	41,702	41,702
Advanced metering infrastructure	18,878	50,765
Renewable/ distributed generation integration	17,274	20,251
C/I building & home energy management	8,865	27,819
EV charging	4,500	7,500
Wide area monitoring & control	244	244
Other	20,359	30,084
TOTAL COST	**337,678**	**476,190**

Note: These are not predictions of actual investment in smart grid; rather, they are estimates of the levels of investment required for 100% saturation.

Source: Adapted from (EPRI, 2011).

An example of how fast the smart grid industry is growing in the Research Triangle is Cary-based ABB. Recently named the Cleantech company of the year (mainly thanks to smart grid), the firm is investing $10 million in a Center of Excellence at North Carolina State University, and $90 million in a new high-voltage cable facility near Charlotte (ABB, 2011). With 120,000 employees worldwide, ABB is now adding more jobs on this continent than in China or India (Burchett, 2011), and a substantial portion will be in the Triangle — which recently became ABB's corporate headquarters for North America. These investments are an indication of how lead firms are responding to the expected growth in smart grid opportunities in coming years.

Conclusion

The United States is among the global leaders in smart grid development. The fast-growing market for smart grid technologies presents valuable business opportunities for U.S. companies large and small, from multinational legacy power firms to specialty start-ups. A striking concentration of the world's leading smart grid vendor firms is found in North Carolina; only California appears to have a substantially larger concentration of relevant firm locations. In addition, North Carolina has an extraordinary combination of assets to harness engineering talent, develop and test smart grid technologies, and apply them in combination with the many efforts across the state to improve energy efficiency and expand the role of renewable energy.

The 13-county Research Triangle Region in particular boasts a natural clustering of at least 60 smart grid firms, including leaders in electric power systems, information technology, core communications, energy management, telecom service, and system integration. Added to these well-established players are a growing number of smaller specialty ventures devoted to developing smart grid innovations. The Triangle is already recognized as a leader in smart grid and well positioned to build on this momentum. With a conservatively estimated 3,000 employees engaged directly with smart grid technologies, the region will likely attract more jobs as lead firms invest further in the rapidly expanding industry.

The Research Triangle Region and the state of North Carolina have a unique opportunity not only to invent, manufacture, and sell smart grid technologies to the global market, but also to implement them here at home. The upcoming merger of Duke Energy and Progress Energy, creating the nation's largest utility, may offer economies of scale that can facilitate smart grid deployment.

To make the most of this opportunity will require targeted policy support, however. In the post-stimulus period it will be important to create a policy environment conducive to further private investment in smart grid. It will also require regulatory reform and, more important, fundamental changes in the electricity sector's prevailing business model, which incentivizes utilities to sell more, not less energy. Such changes will require a coordinated effort on the part of policy makers and regulators, as well as other stakeholders including industry and non-profit institutions. No less important is education of the public so that consumers not only understand the need to update the outdated electric system, but also recognize the potential of the smart grid to reduce energy use and CO_2 emissions, deliver reliable power, stimulate innovation, and create local jobs.

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Appendix: Matrix of Research Triangle smart grid capabilities (firm by firm)

	Company[13]	IT & comm technology integration[14]	C/I bldg or home energy management	Advanced metering infrastructure	EV charging	Transmission enhancement	Distribution grid management	Renewable & distributed generation integration	Wide area monitoring & control
1	**3DFS Power Solutions**							•	
2	**ABB**[15] $$$$$[16] ☺☺☺☺☺[17]	• Δ	Δ	**[18]	•	• Δ	• Δ	• Δ	• Δ
3	**Accenture**[19] $$$$$ ☺☺☺☺☺	Δ	Δ	Δ		Δ	Δ		

[13] Information is based on self-reporting by firms. Black dot (•) refers to hardware; red delta (Δ) refers to software and/or services.

[14] Technology categories are from IEA, 2011 based on definitions from DOE's National Energy Technology Laboratory (NETL) and the National Institute of Standards and Technology (NIST).

[15] Sales and employees are total company figures, intended to show relative scale of firms.

[16] Sales size: $=0-100M; $$=100-500M; $$$=500M-1B; $$$$=1-10B; $$$$$=10B+

[17] Employee size: ☺=1-500; ☺☺=501-1000; ☺☺☺=1001-5000; ☺☺☺☺=5001-10000; ☺☺☺☺☺=10000+

[18] Involved through partnerships with Silver Spring Networks, Elster, Sensus and Itron; invested in Trilliant; has performed interoperability testing with Freewave, GE MDS, Tropos, Alcara, and others.

[19] Provides consulting and technology services.

	Company	IT & comm tech integration	C/I bldg or home energy mgt	Advanced metering infrastructure	EV charging	Transmission enhancement	Distribution grid mgt	Renewable & distributed generation integration	Wide area monitoring & control
4	**Alcatel-Lucent** $$$$$ ☺☺☺☺☺	• ∆							
5	**AT&T** $$$$$ ☺☺☺☺☺	∆							
6	**Aviat Networks** $$ ☺☺☺	• ∆							
7	**Black & Veatch** $$$$ ☺☺☺☺	∆							
8	**Brocade** $$$$ ☺☺☺	• ∆							
9	**Cisco Systems** $$$$$ ☺☺☺☺☺	∆	∆		∆				
10	**Consert** $ ☺	•	• ∆	∆	∆				

	Company	IT & comm tech integration	C/I bldg or home energy mgt	Advanced metering infrastructure	EV charging	Transmission enhancement	Distribution grid mgt	Renewable & distributed generation integration	Wide area monitoring & control
11	**Consonus Technologies**[20] $ ☺	Δ							
12	**Control Infotech**						• Δ		
13	**Cree** $$$ ☺☺☺	•	•						
14	**Cypress Semiconductor** $$$ ☺☺☺	•							
15	**Delta Electronics** $$$$ ☺☺☺☺	•	•			•			
16	**DNA Group**						•		

[20] A Midas Medici Group Holdings, Inc. company

	Company	IT & comm tech integration	C/I bldg or home energy mgt	Advanced metering infrastructure	EV charging	Transmission enhancement	Distribution grid mgt	Renewable & distributed generation integration	Wide area monitoring & control
17	**Doble Engineering Co.** ☺						Δ		
18	**Eaton** $$$$$ ☺☺☺☺☺	• Δ	Δ		•	•	•		
19	**Elster Solutions**[21] $$$$ ☺☺☺☺	• Δ	Δ	• Δ	• Δ		• Δ	Δ	• Δ
20	**EMC Corporation** $$$$$ ☺☺☺☺☺	•							
21	**Freescale Semiconductor** ☺☺☺☺☺	•		• [22]					
22	**GE** $$$$$ ☺☺☺☺☺	•	• Δ	• Δ	•	• Δ	•	•Δ	

[21] EV charging is part of Elster's suite of Smart Grid solutions named EnergyAxis

[22] Provides AMI components

	Company	IT & comm tech integration	C/I bldg or home energy mgt	Advanced metering infrastructure	EV charging	Transmission enhancement	Distribution grid mgt	Renewable & distributed generation integration	Wide area monitoring & control
23	**Google** $$$$$ ☺☺☺☺☺		Δ						
24	**Green Energy Corp** $ ☺	Δ		Δ		Δ	Δ	Δ	Δ
25	**GRIDiant** $ ☺	•	Δ				Δ		
26	**Honeywell** $$$$$ ☺☺☺☺☺		• Δ	Δ					
27	**IBM** $$$$$ ☺☺☺☺☺	Δ	Δ	Δ			Δ		Δ
28	**Itron** $$$$ ☺☺☺☺	• Δ	• Δ	• Δ	• Δ[23]		• Δ	Δ	
29	**Johnson Controls** $$$$$ ☺☺☺☺☺	•	• Δ						

[23] Itron is now in the concept development stage on their products for EV charging.

	Company	IT & comm tech integration	C/I bldg or home energy mgt	Advanced metering infrastructure	EV charging	Transmission enhancement	Distribution grid mgt	Renewable & distributed generation integration	Wide area monitoring & control
30	**KEMA**[24] **$$** ☺☺☺	Δ	Δ	Δ	Δ	Δ	Δ	Δ	
31	**Majorpower**							•	
32	**MasTec** $$$$ ☺☺☺☺	Δ							
33	**MegaWatt Solar** $ ☺							•	
34	**Microcell** $ ☺							•	
35	**NEXANT, INC.** ☺		Δ			Δ	Δ		
36	**Nitronex** $ ☺	•							

[24] Provides consulting and bench testing services.

	Company	IT & comm tech integration	C/I bldg or home energy mgt	Advanced metering infrastructure	EV charging	Transmission enhancement	Distribution grid mgt	Renewable & distributed generation integration	Wide area monitoring & control
37	**Plotwatt** ☺		Δ						
38	**Power Analytics**[25] ☺	Δ	Δ	Δ			Δ	Δ	
39	**Power Secure** $ ☺		•	Δ			•	Δ	
40	**Quanta Technology** $ ☺	Δ		Δ		Δ	Δ	Δ	Δ
41	**Red Hat** $$$ ☺☺☺	Δ							
42	**SAP** $$$$$ ☺☺☺☺☺	Δ		Δ					
43	**SAS Institute** $$$$$ ☺☺☺☺		Δ	Δ					

[25] Power Analytics was formerly EDSA Micro.

	Company	IT & comm tech integration	C/I bldg or home energy mgt	Advanced metering infrastructure	EV charging	Transmission enhancement	Distribution grid mgt	Renewable & distributed generation integration	Wide area monitoring & control
44	**Schneider Electric** $$$$$ ☺☺☺☺☺	•	• Δ		•	•	•		
45	**Sensus** $$$ ☺☺☺	• Δ		• Δ			• Δ		• Δ
46	**Siemens Energy** $$$$$ ☺☺☺☺☺		• Δ	Δ	• Δ	• Δ	• Δ	• Δ	•
47	**Sprint** $$$$$ ☺☺☺☺☺	Δ							
48	**STMicro-electronics**[26] $$$$$ ☺☺☺☺☺	•						•	
49	**Sun Microsystems**[27] $$$$$ ☺☺☺☺☺	• Δ							

[26] Among the world's largest semiconductor companies

[27] An Oracle Company

	Company	IT & comm tech integration	C/I bldg or home energy mgt	Advanced metering infrastructure	EV charging	Transmission enhancement	Distribution grid mgt	Renewable & distributed generation integration	Wide area monitoring & control
50	**Tantalus Systems** $ ☺	Δ	• Δ	• Δ					
51	**TE Connectivity**[28] $$$$$ ☺☺☺☺☺					•	•		
52	**Telit Wireless Solutions** $ ☺	•							
53	**Triangle MicroWorks**	Δ							
54	**Truveon** $ ☺		• Δ						
55	**Underwriter Laboratories**[29] $$$ ☺☺☺☺	Δ	Δ	Δ	Δ			Δ	

[28] TE Connectivity was formerly Tyco Electronics

[29] Develops standards and safety procedures for products

	Company	IT & comm tech integration	C/I bldg or home energy mgt	Advanced metering infrastructure	EV charging	Transmission enhancement	Distribution grid mgt	Renewable & distributed generation integration	Wide area monitoring & control
56	**Virtual Computing Environment**	Δ							
57	**Ventyx**[30] $$$$$ ☺☺☺☺☺	Δ		Δ					
58	**Verizon** $$$$$ ☺☺☺☺☺	Δ							
59	**Wesco Distribution Inc.**[31] $ ☺	•				•	•		

Note: Sector is highly dynamic. Matrix reflects status of firms based on data collected as of April 2011.

Source: Information is based on self-reporting by firms via interviews and websites.

[30] An ABB company

[31] Distributor only